MULTIMEDIA UNIVERSITY

FINAL EXAMINATION

TRIMESTER 2, 2018/2019

EEL4106 – HIGH VOLTAGE ENGINEERING
(LE)

15 MARCH 2019
3.00 p.m – 5.00 p.m
(2 Hours)

INSTRUCTIONS TO STUDENT

1. This question paper consists of 4 pages including the cover page with 4 Questions only.

2. Answer **ALL** questions. The distribution of the marks for each question is given.

3. Please write all your answers in the Answer Booklet provided.

Question 1

(a) A rectifier is a circuit which converts the Alternating Current (AC) input power into a Direct Current (DC) output power. The input power supply may be either a single-phase or a multi-phase supply with the simplest of all the rectifier circuits being that of the half-wave rectifier.
  (i)   Draw a half-wave rectifying circuit.   [3 marks]
  (ii) Prove that the ripple voltage, δV, is dependent upon the load current, I_L and the circuit parameters (frequency, f and capacitor, C).   [5 marks]

(b) If using a cascaded transformer, an accidental and unwanted resonance in the testing circuit will amplify the test voltage leading to dangerous explosion. Thus, a resonance transformer is preferred as a means of overcoming the accidental and unwanted resonance to which the more conventional test sets are more prone. List out **THREE** advantages of a high voltage series resonant transformer.   [6 marks]

(c) For voltages higher than 400kV, it is desired to cascade 2 or more transformers depending upon the voltage requirements. The tertiary winding of first stage has the same number of turns as the primary winding, and feeds the primary of the second stage transformer.
  With a proper labelling,
  (i)   Draw the equivalent circuit of 3- stages cascaded transformer.   [5 marks]
  (ii)   Prove that $X_{res} = 14X_p + 3X_s + 5X_t$, where X_p, X_s and X_t are the reactances of the primary, secondary and tertiary windings, respectively.   [3 marks]
  (iii) Compute the resulting short circuit reactances of the cascaded transformer if the short circuit reactance of each transformer is given as: $X_{ps} = 4\%$; $X_{pt} = 5\%$; $X_{st} = 6\%$.   [3 marks]

Question 2

(a) One of the peak voltage measurements used in high voltage systems is sphere gap. List out **FOUR** sphere gap specifications.   [4 marks]

(b) A Chubb and Fortescue circuit has been designed to measure the peak value of a high AC voltage. The mean value of the current read by the moving coil meter is 12 mA. The capacitance used in the circuit is 0.002 μF.
  (i)   Draw the circuit.   [4 marks]
  (ii) Calculate the peak value of the high AC voltage at 50 Hz.   [2 marks]

(c) Briefly explain the reasons why inductance circuit is not used as the voltage divider for voltage measurement.   [3 marks]

(d) List out **TWO** typical types of resistive shunt used for high impulse current measurements in order to reduce the stray capacitive and inductive effect.
                                                                              [2 marks]

Continued...

(e) Define the following terms used in **IEC 60060-1:2010: High-voltage test techniques - Part 1: General definitions and test requirements.**
   (i)   Self-restoring insulation
   (ii) Lightning overvoltage

[4 marks]

(f) Explain briefly the 50% dry impulse flash over test on the insulator.   [6 marks]

Question 3

(a) Two of the properties of dielectric are; loss angle and dissipation factor. List out the other **THREE** properties of dielectric.   [3 marks]

(b) If an electric field in an insulating medium is increased, the breakdown of the insulator would occur. One of the mechanisms for breakdown in gases is ionization on the surface of the electrode, where the electron can appear in a gas from the cathode. Liberation of an electron from a metal surface requires a definite amount of energy called the work function which varies from metal to metal. List out **FOUR** processes involved of which energy can be imparted to metal.   [8 marks]

(c) A steady current of 1120 μA flows through a gas between two plane electrodes separated by a distance of 0.4 cm when an AC voltage of 8 kV is applied. Determine the Townsend's first ionization coefficient if a current of 112 μA flows when the distance of separation is reduced to 0.3 cm and the field is kept constant at the previous value.   [4 marks]

(d) List out **THREE** advantages of liquid dielectric in comparison to gas and solid dielectrics.   [3 marks]

(e) The current-field characteristic curve for a hydrocarbon liquid is shown in Fig. Q3. As can be seen in the figure, the curve has three distinct regions. Briefly describe these three regions.   [7 marks]
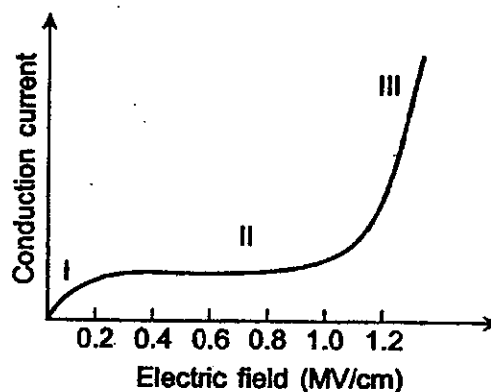
Fig.Q3

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Question 4

(a) Insulation coordination is the correlation of the insulation of electrical equipment and circuit with the characteristics of the protective devices such that the insulation is protected from excessive overvoltages. Thus, equipment insulation must withstand voltage levels in excess of the breakdown voltage of the protective device.

      (i)   What are the basic philosophies of protection of power system equipment against overvoltages?   [3 marks]

      (ii)   State the ideal and practical characteristics of shunt protective devices.

                                                            [9 marks]

      (iii)   Draw the volt-time characteristics of equipment to be protected and protective devices.   [3 marks]

(b) A rectangular voltage wave of 2800 kV is traveling along a line of surge impedance 250 Ω towards a lightning arrester. The arrester protective level is 1800 kV and is assumed to be fairly constant at all current values discharged by the arrester. Calculate the following:

      (i)   the current flowing through the line before the surge voltage reaches the arrester terminal   [1 mark]

      (ii)   the current through the arrester   [3 marks]

      (iii)   reflected current in the line, I_2, reflected voltage in the line, V_2, refracted voltage into the arrester, V_3, reflected coefficient of voltage and refraction coefficient of voltage, and   [5 marks]

      (iv)   the arrester's resistance.   [1 mark]

End of Paper.